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**Bassett**

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(54) **AGRICULTURAL APPARATUS WITH  
HYBRID SINGLE-DISK, DOUBLE-DISK  
COULTER ARRANGEMENT**

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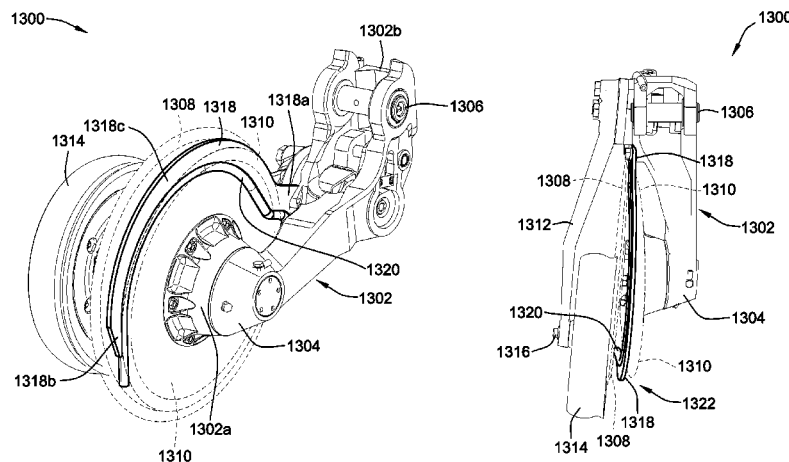
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(57) **ABSTRACT**

An agricultural row unit assembly includes an attachment  
frame configured for attachment to a tow bar that is movable  
in a direction of travel. A proximal end of a swing-arm is  
coupled to the attachment frame, and an opener disk is  
mounted to and offset from a distal end of the swing-arm for  
forming a furrow. A deflecting disk is mounted to the distal  
end for deflecting debris from entering the furrow, and is  
mounted between the distal end of the swing-arm and the  
opener disk. The deflecting disk has a top peripheral edge  
spaced away from a top peripheral edge of the opener disk. A  
support bracket is attached as a cantilevered structure depend-  
ing from the proximal end of the swing arm and extends in a  
space between the top peripheral edges. A tube is routed long  
the support bracket for dispensing a material into the furrow.

**20 Claims, 17 Drawing Sheets**



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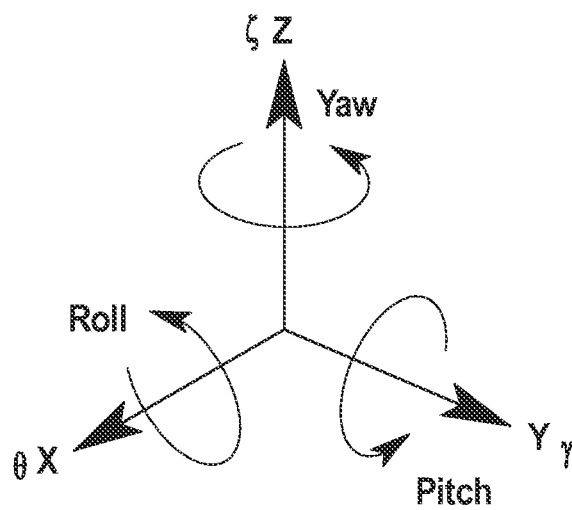
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FIG. 1



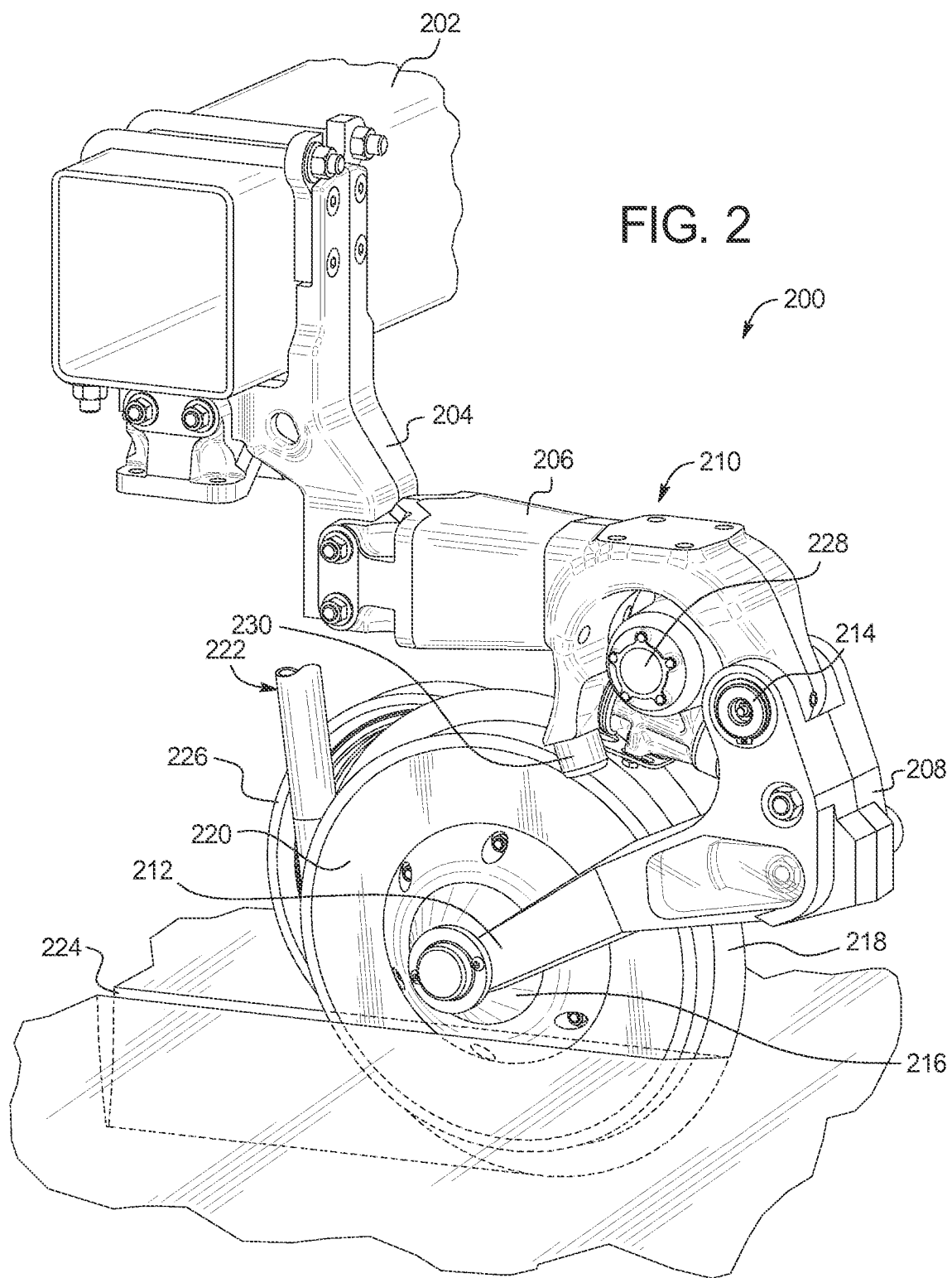
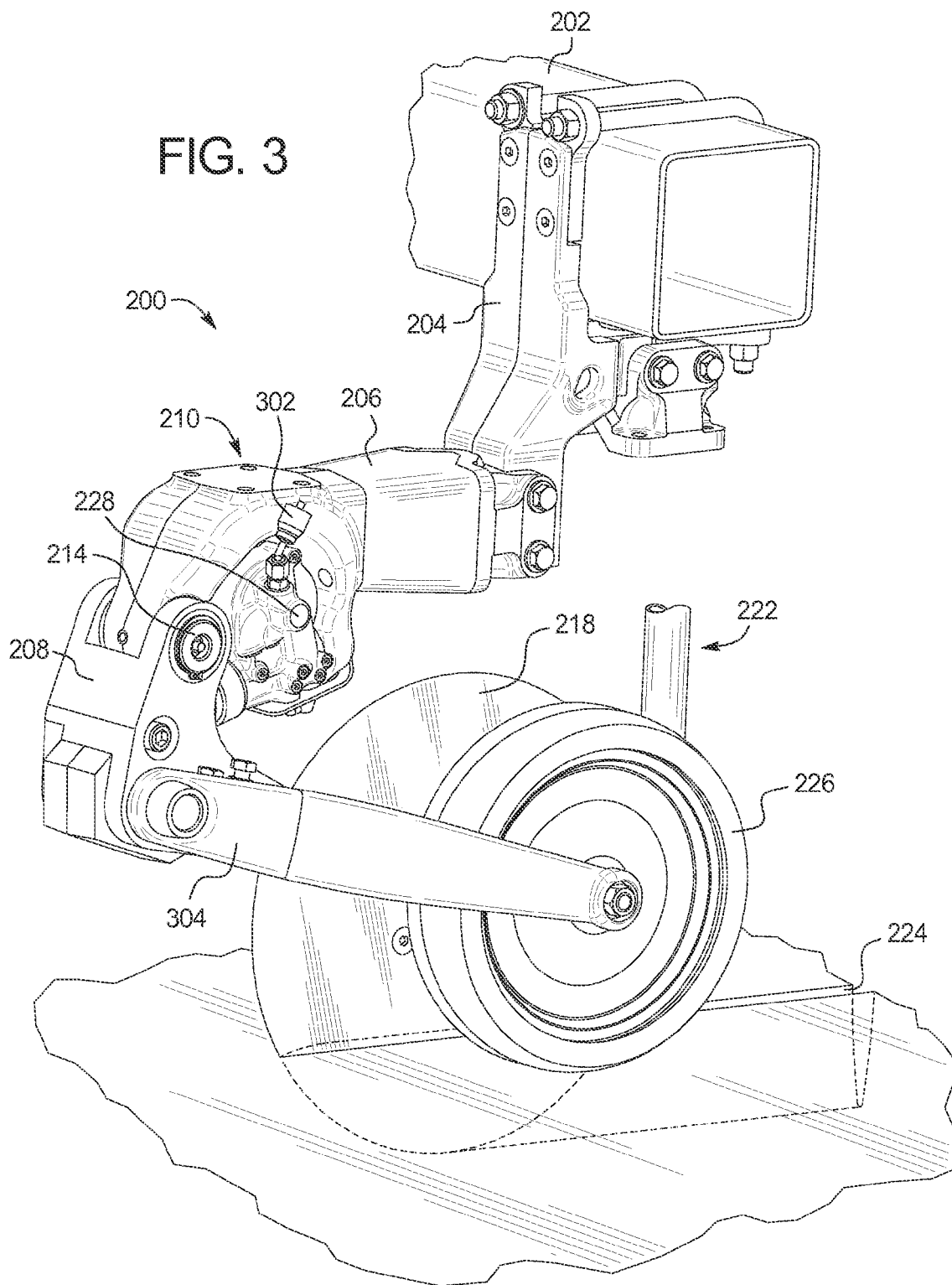


FIG. 3



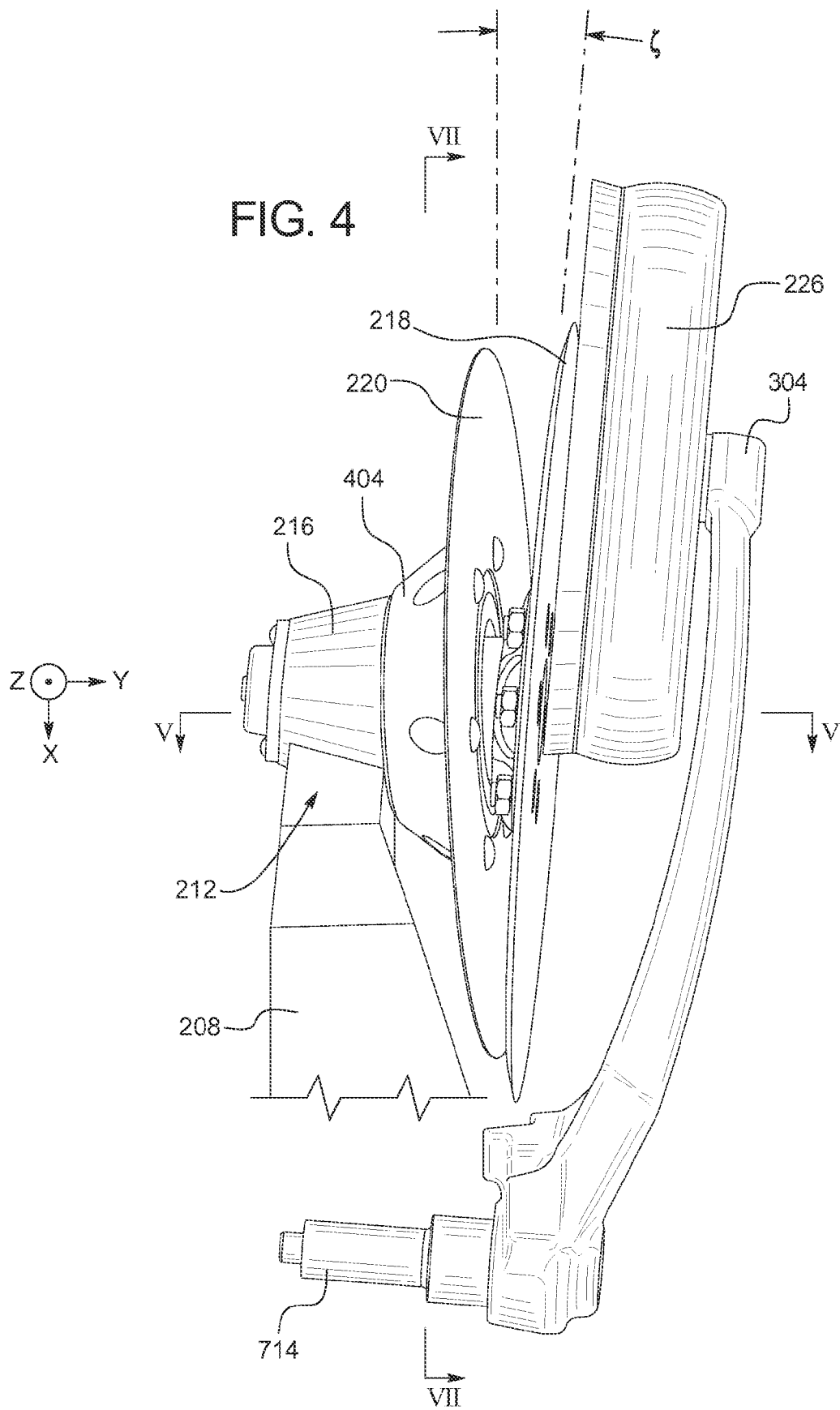
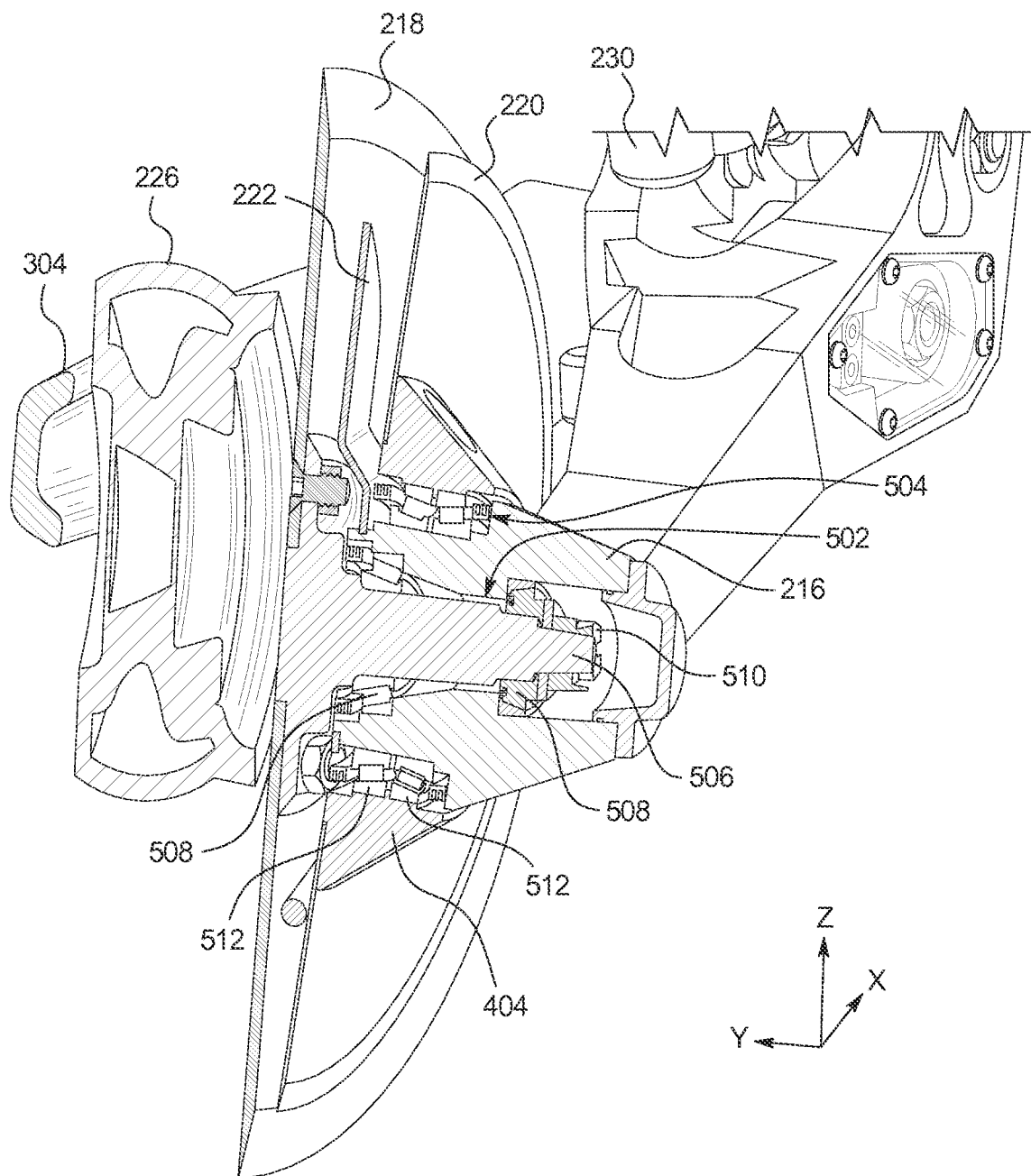




FIG. 5



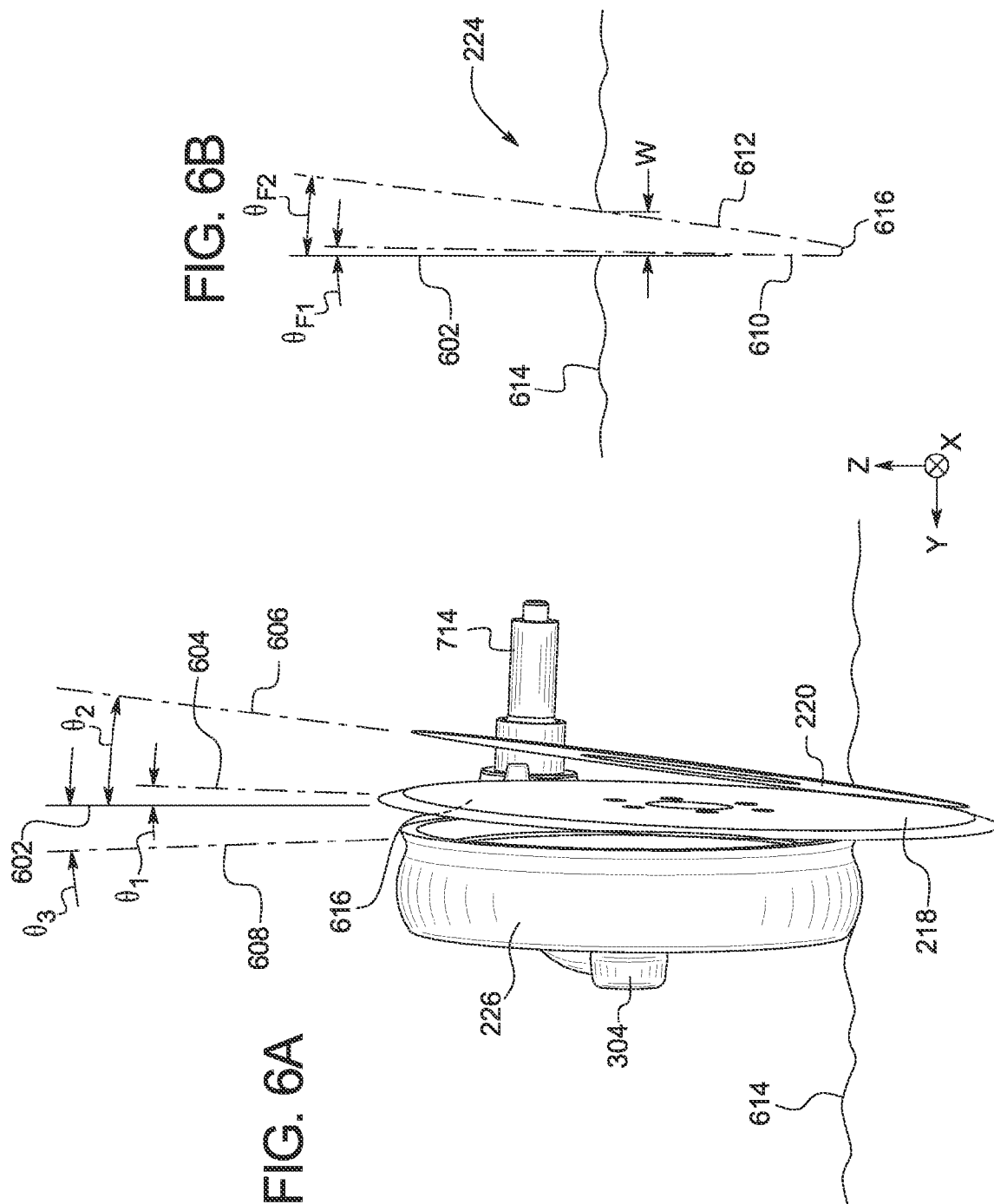
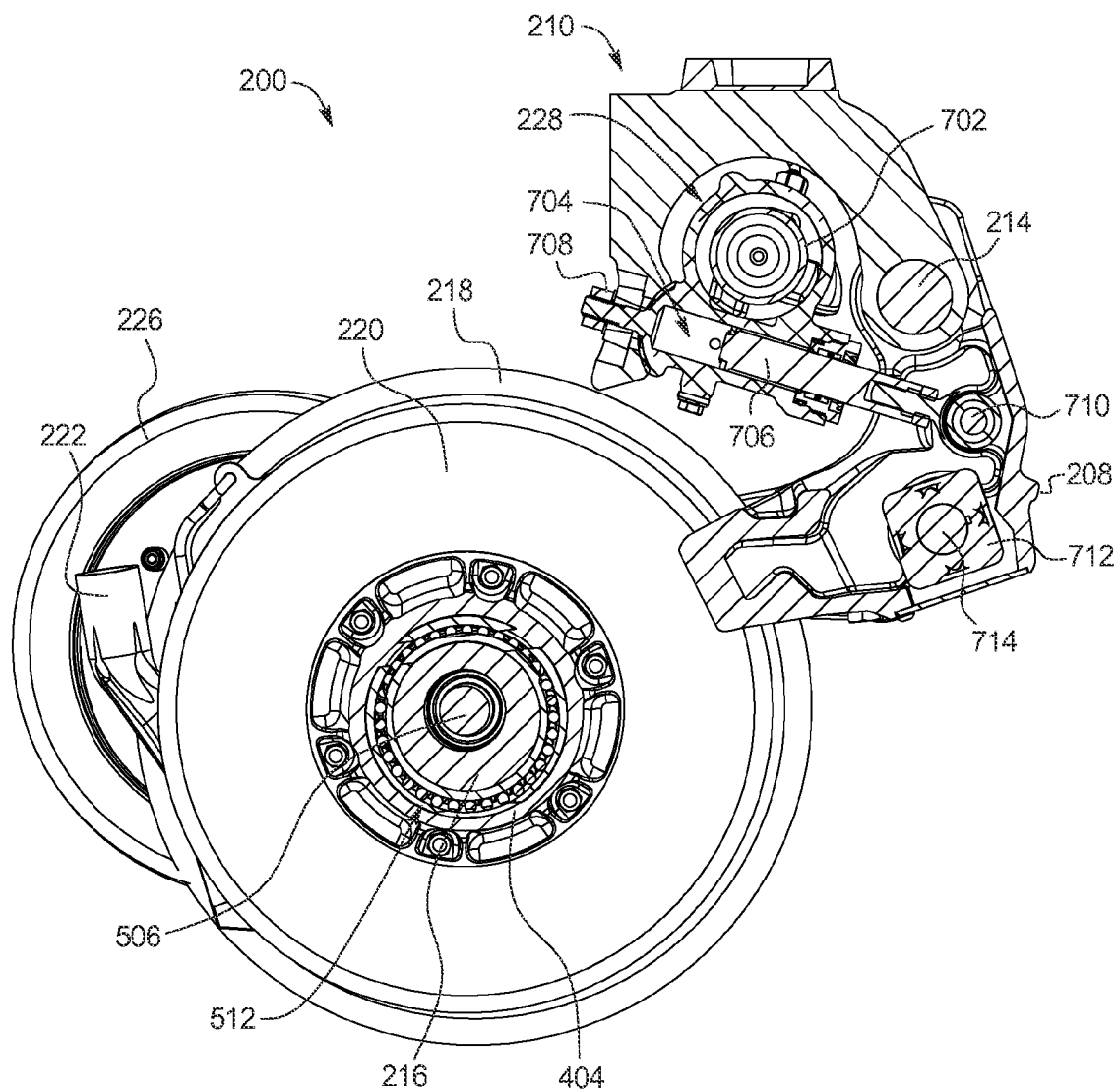
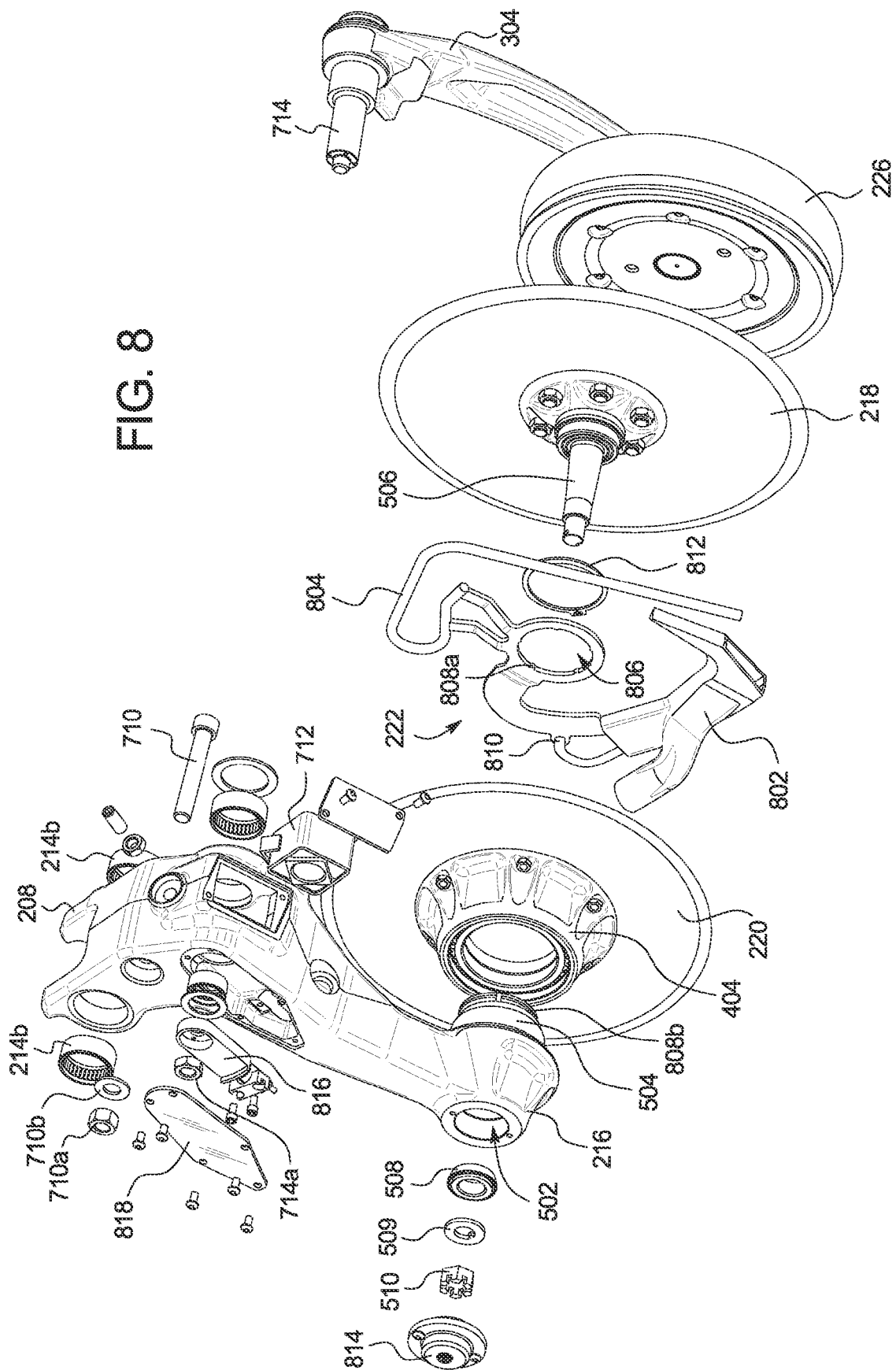
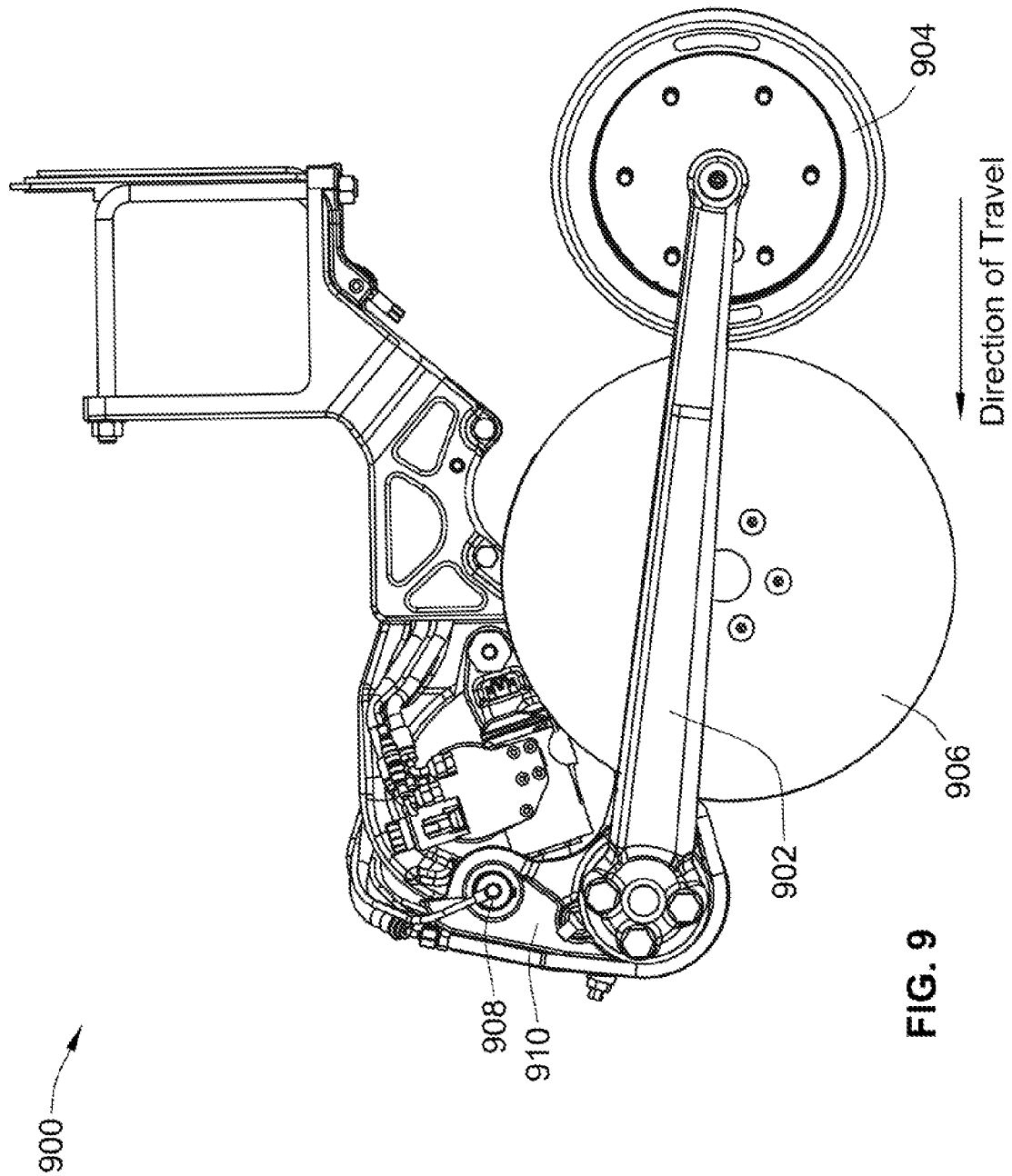
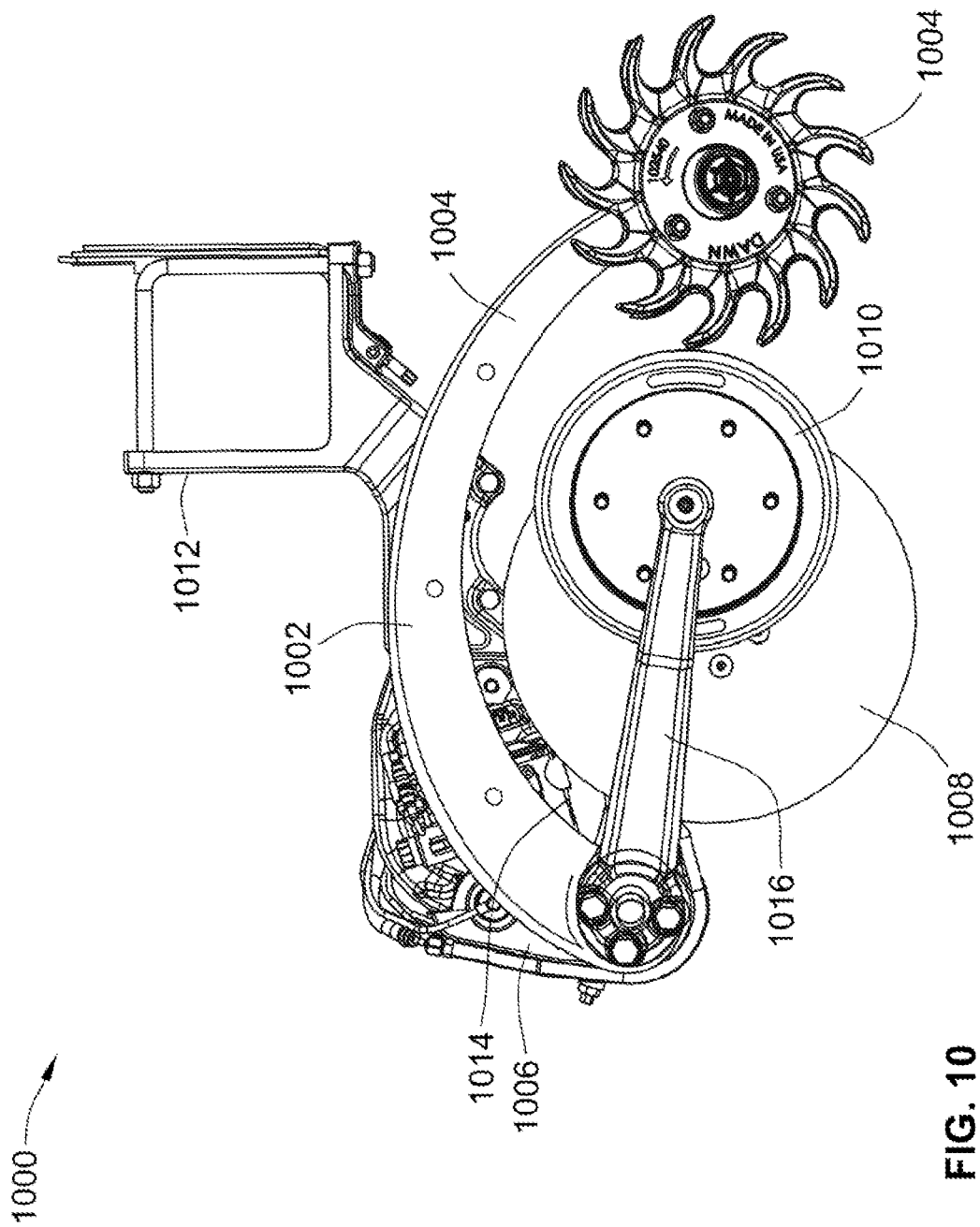


FIG. 7









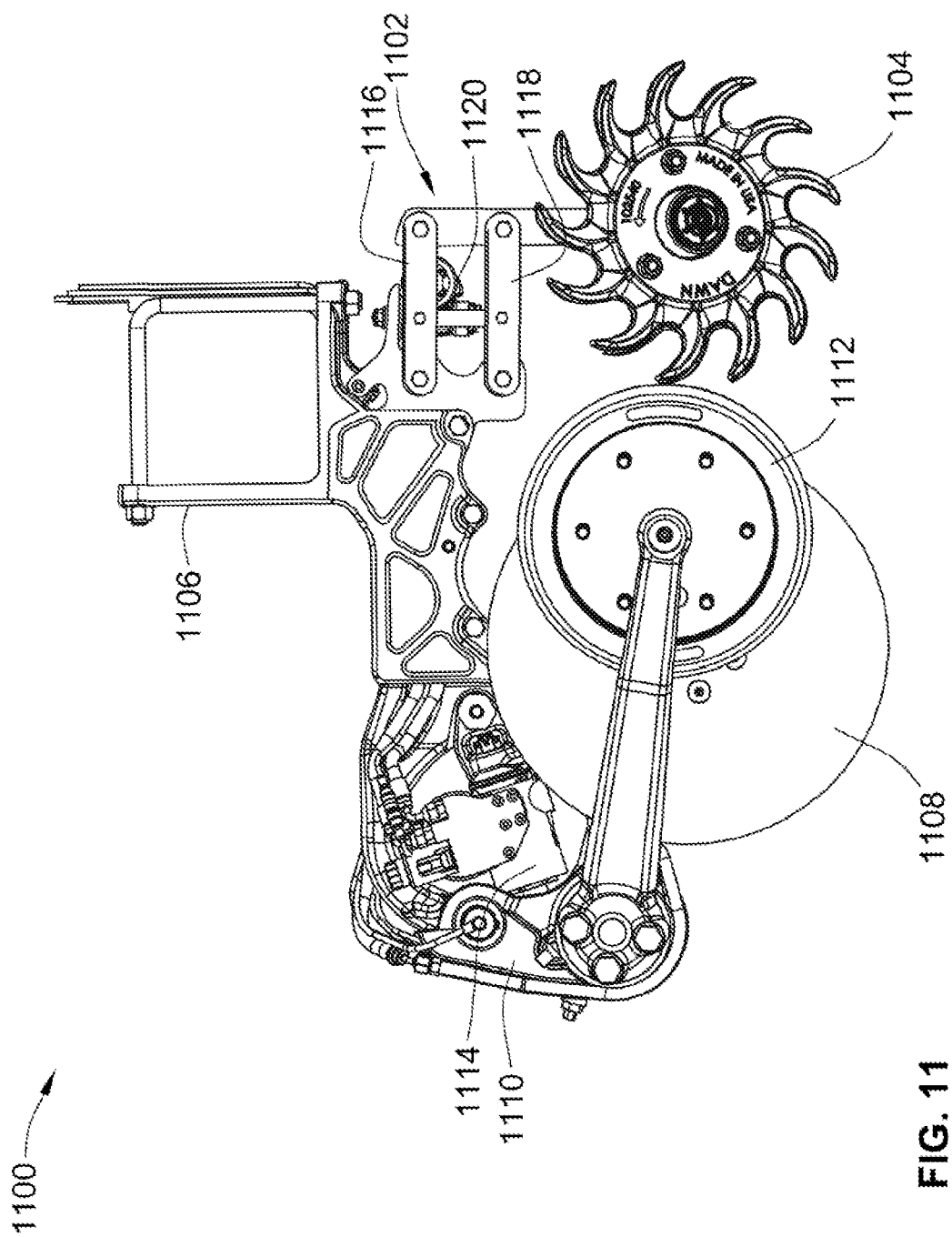


FIG. 11

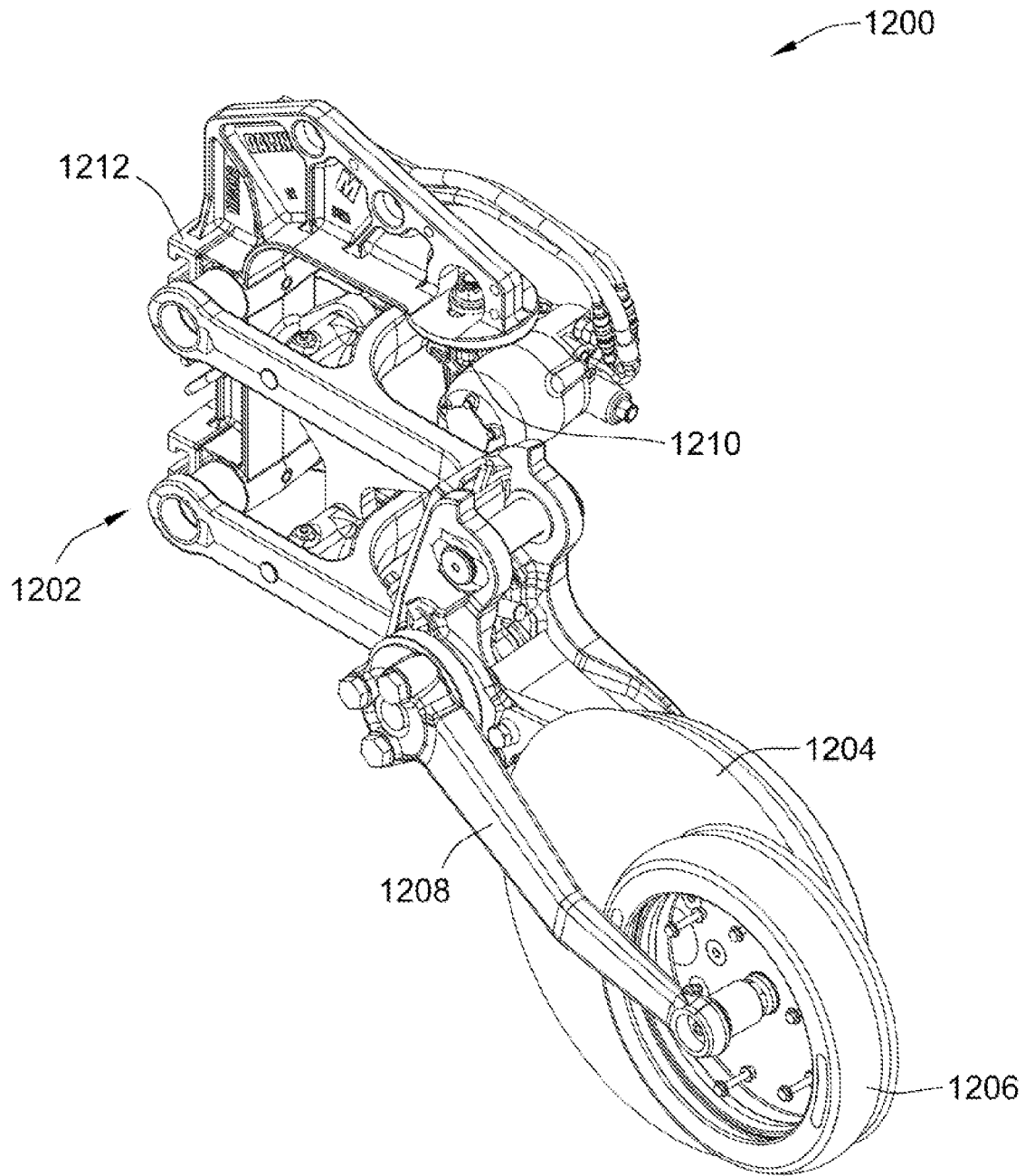


FIG. 12



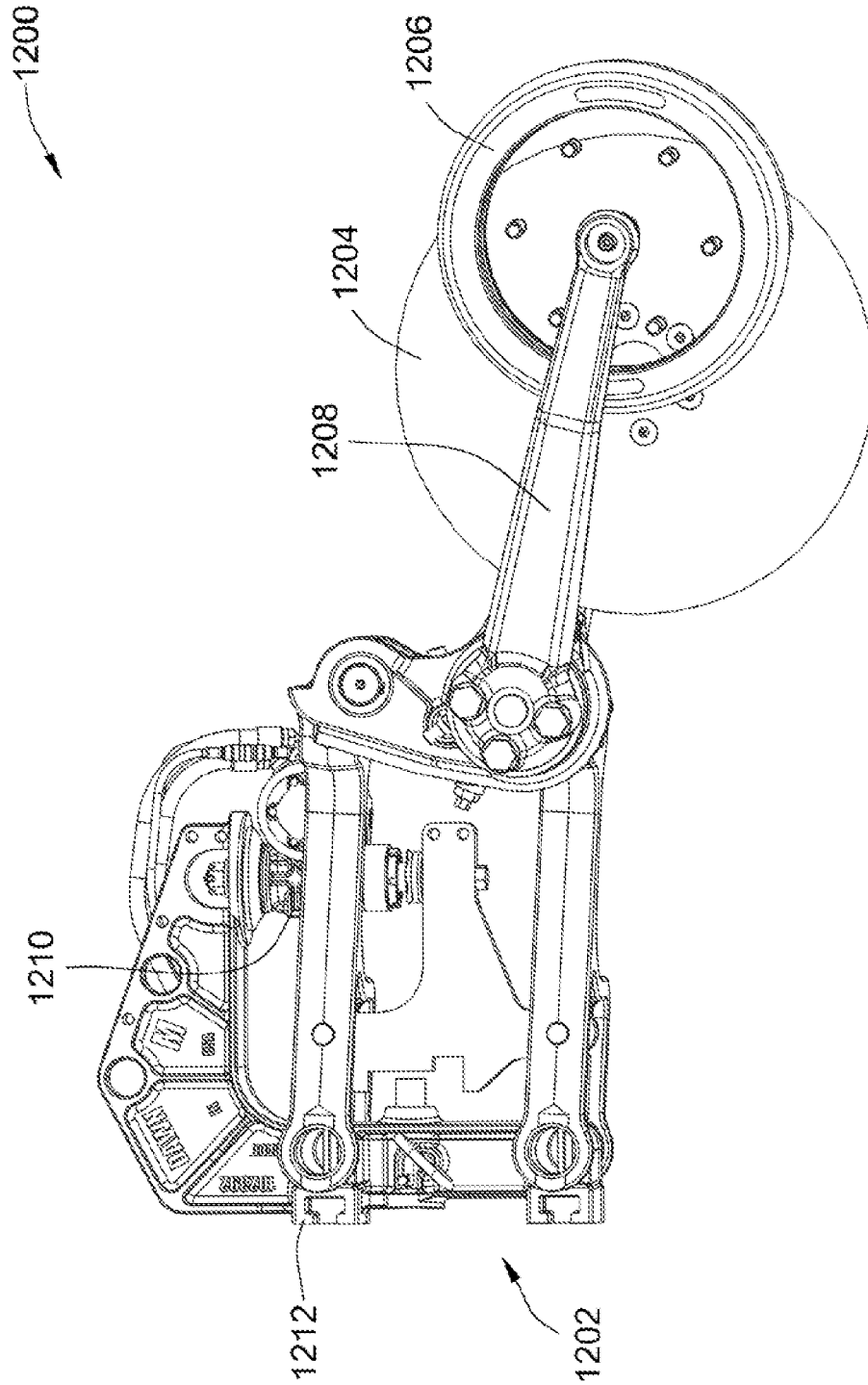


FIG. 13

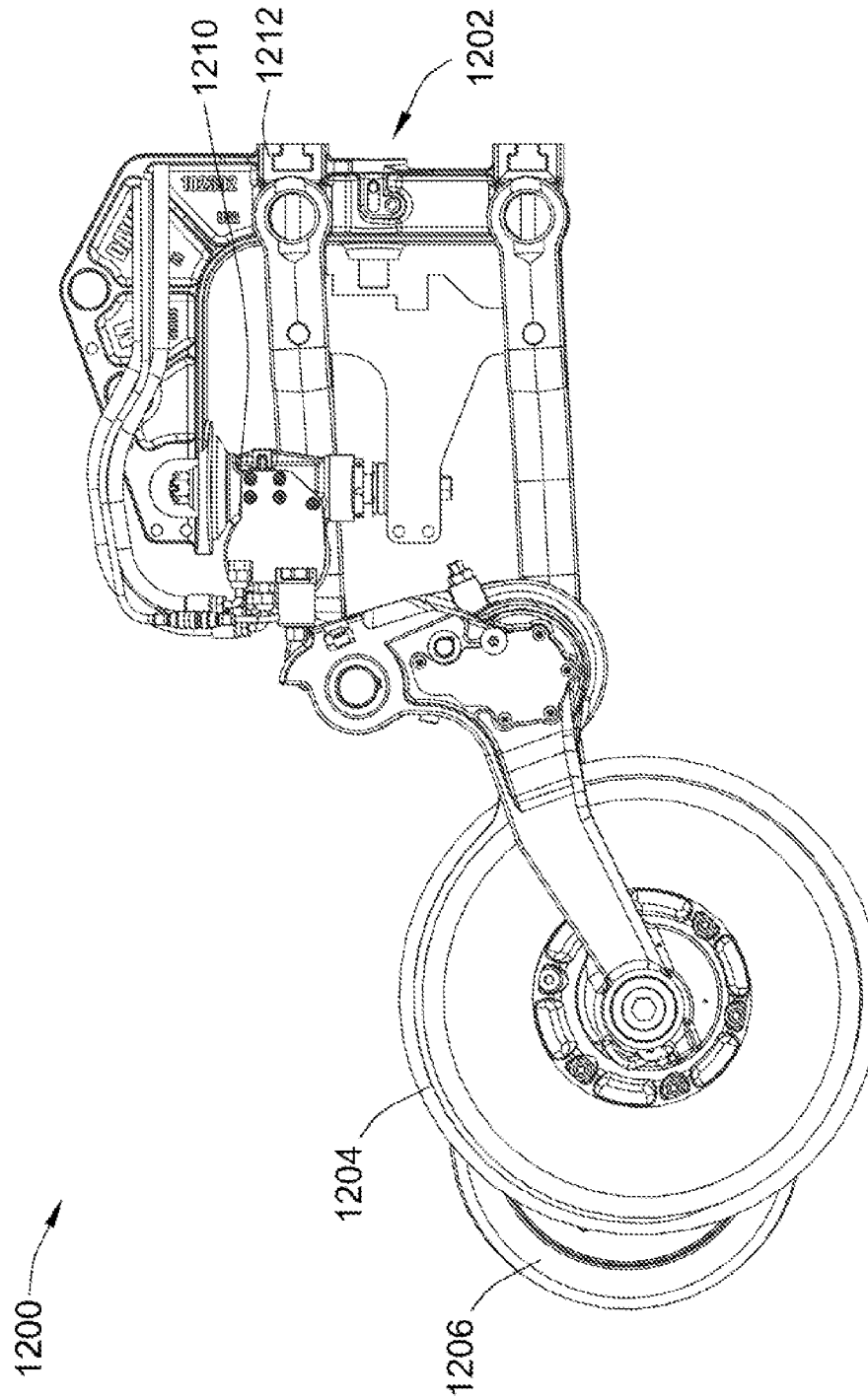
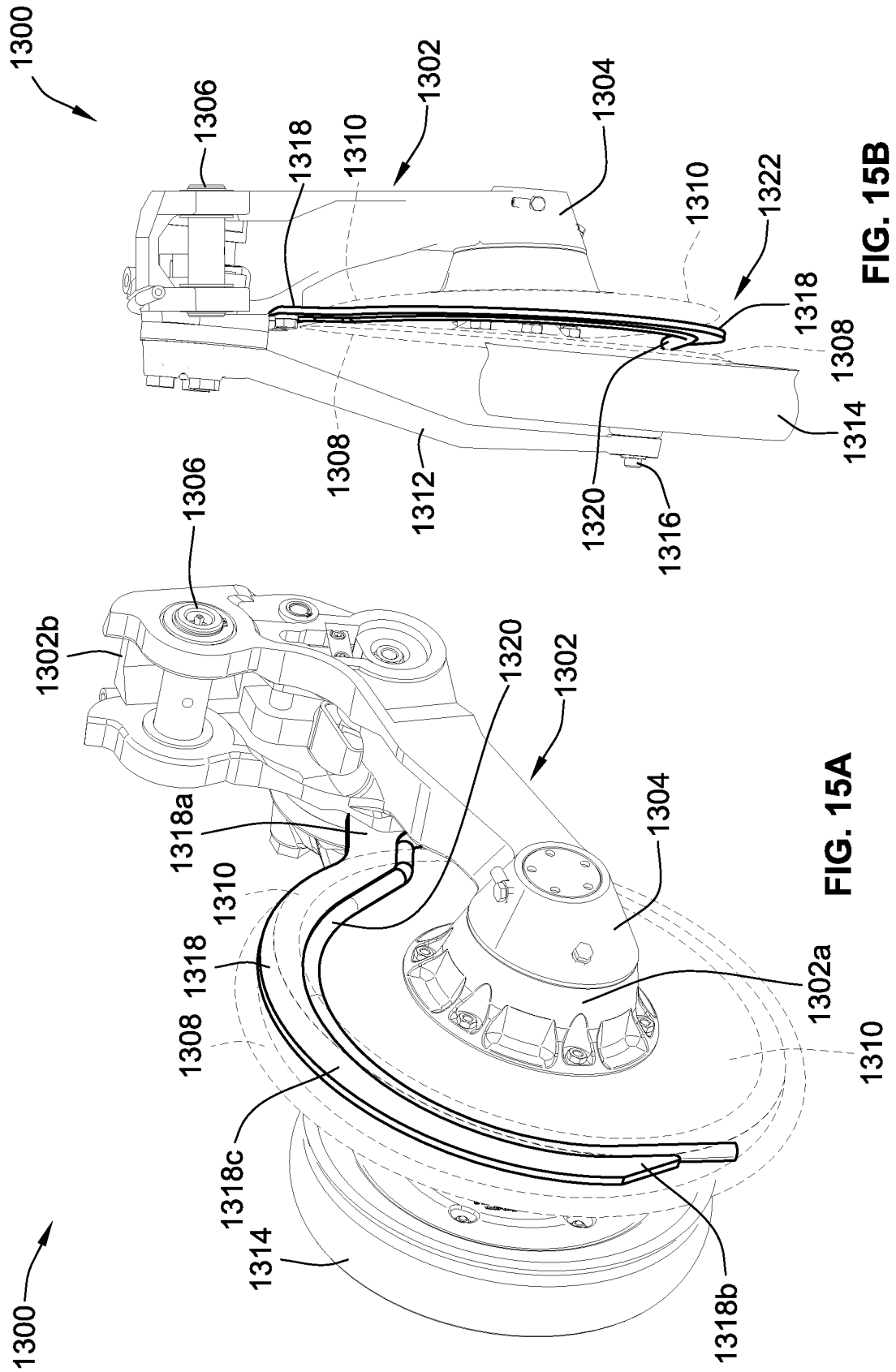


FIG. 14



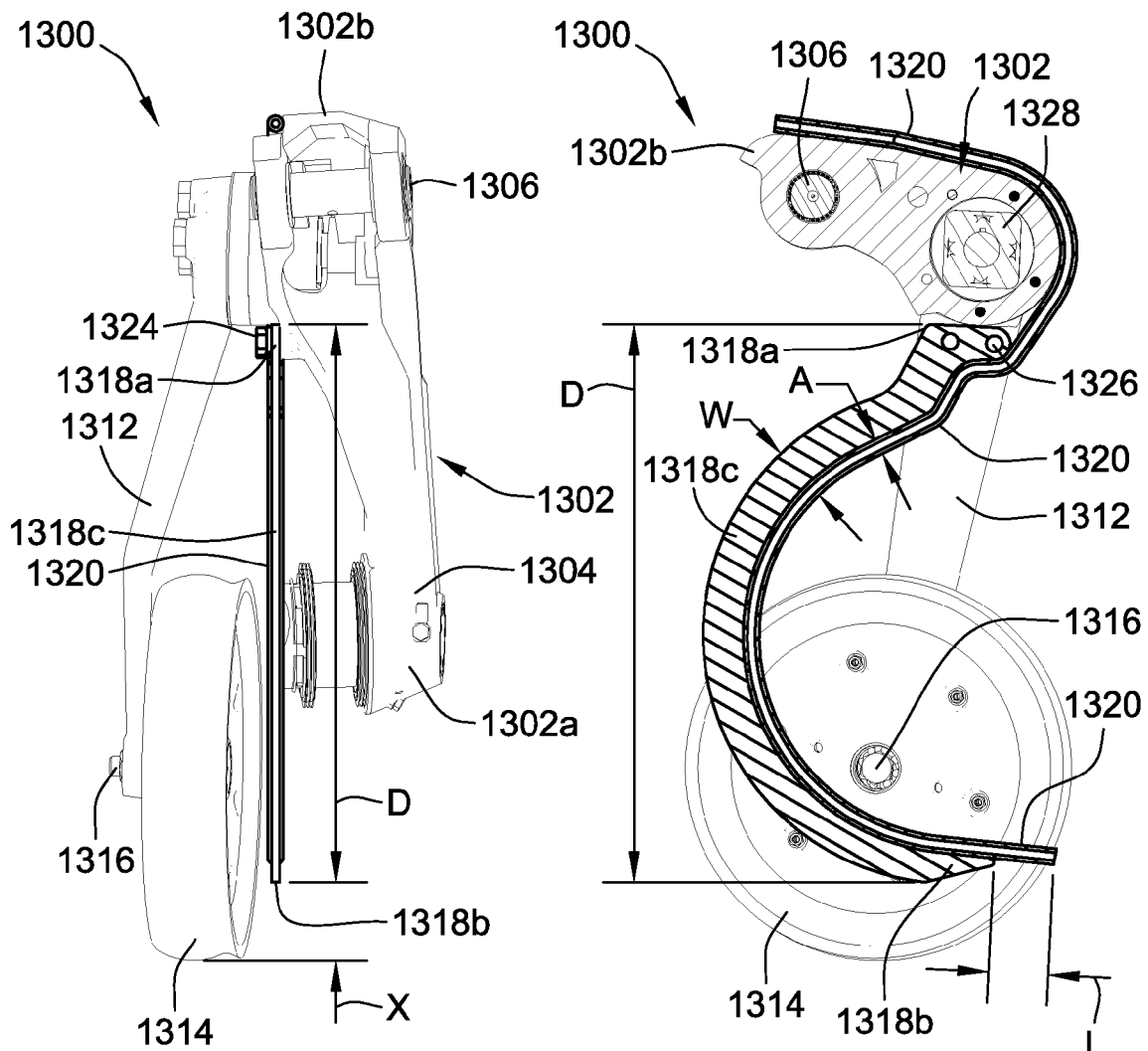


FIG. 16A

FIG. 16B

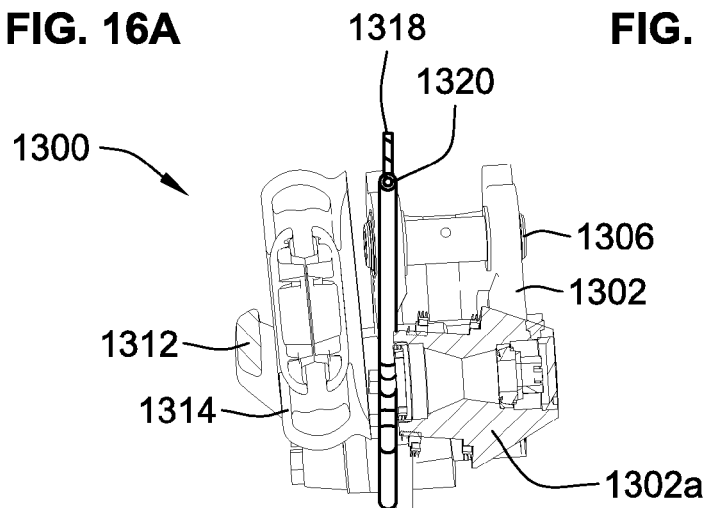


FIG. 16C

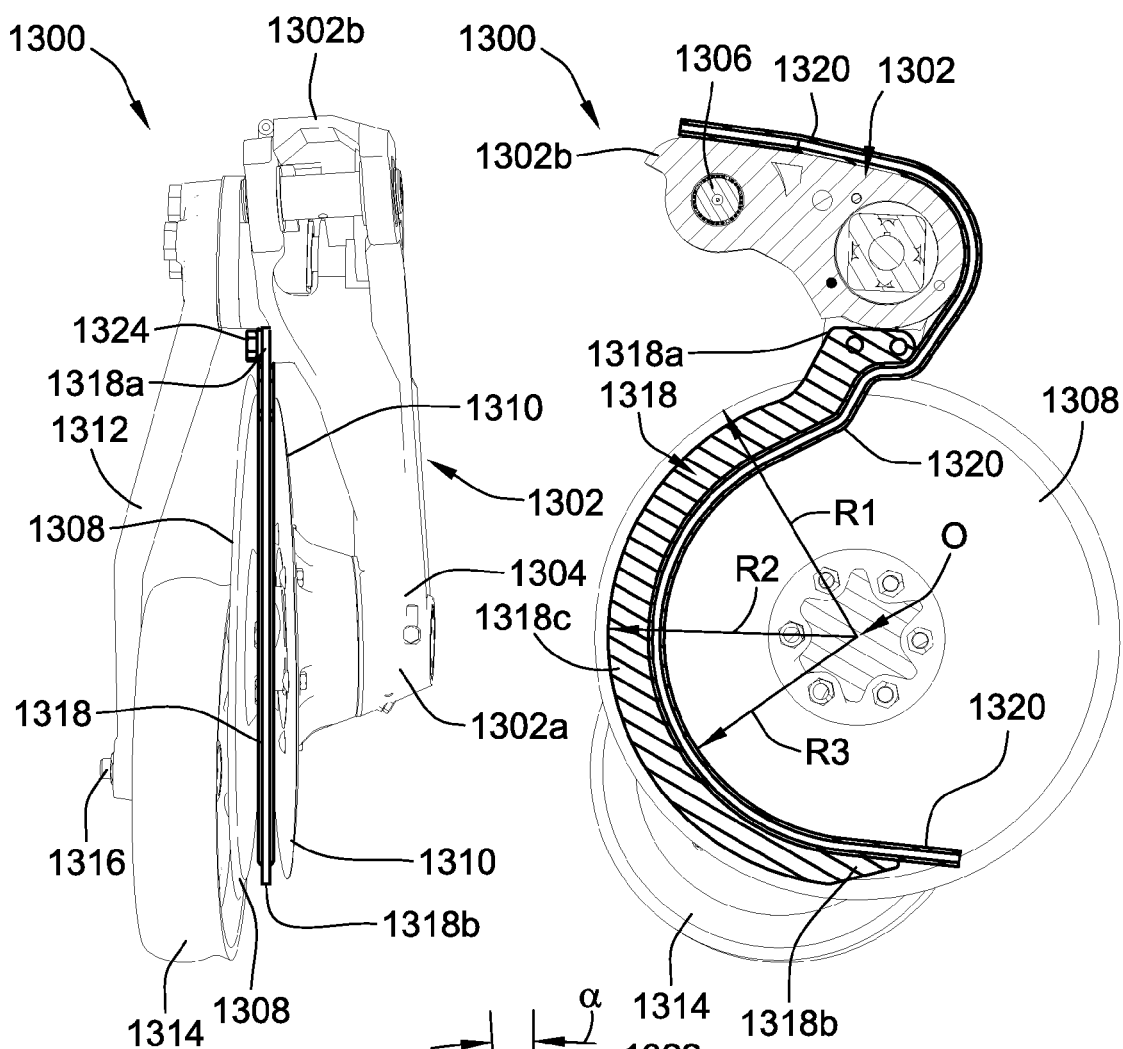


FIG. 17A

FIG. 17B

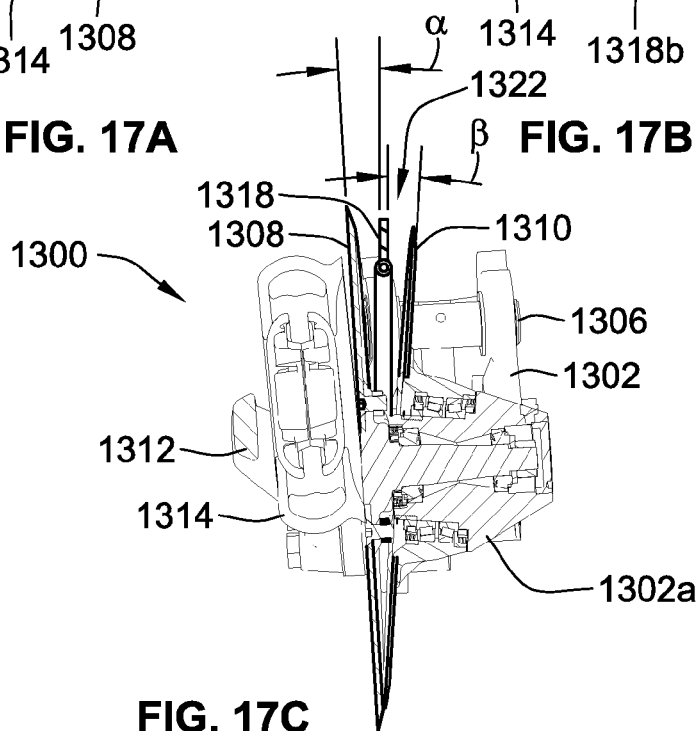


FIG. 17C

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# AGRICULTURAL APPARATUS WITH HYBRID SINGLE-DISK, DOUBLE-DISK COULTER ARRANGEMENT

## CROSS-REFERENCE TO RELATED APPLICATION

This application is a continuation of U.S. patent application Ser. No. 14/059,620, filed on Oct. 22, 2013, for an "Agricultural Apparatus With Hybrid Single-disk, Double-Disk Coulter Arrangement," which is a continuation-in-part of U.S. patent application Ser. No. 13/757,516, filed on Feb. 1, 2013, for an "Agricultural Apparatus With Hybrid Single-Disk, Double-Disk Coulter Arrangement," each of which is incorporated by reference herein in their entirety.

## FIELD OF THE INVENTION

The present invention relates generally to agricultural equipment and, more particularly, to a row crop unit having a disk opener.

## BACKGROUND OF THE INVENTION

In agricultural applications, farmers have typically used a single-disk or double-disk opener for opening a furrow, roughly of a parabolic cross-section, in which material is deposited (such as seed or fertilizer).

Single-disk openers use one disk to cut and shape the furrow. A material shoe is generally disposed behind a leading edge of the disk and is used to deposit material in the furrow. The use of a single disk to open the furrow requires minimal down-pressure to be applied in order to open the furrow. However, disadvantages arise when debris falls into the furrow before the material shoe has passed.

Alternatively, double-disk openers use two disks to cut and shape the furrow. Typically, the two disks form a V-shape with the material shoe in-between. The V-shaped arrangement helps protect the material shoe from debris entering the furrow, but requires much higher down-pressure to be applied in order to cut the furrow. This increase of down-pressure leads to increased wear and tear on the disk opener and increased fuel consumption.

Traditionally, constant down-pressure is applied by the single-disk or double-disk opener using a resilient member such as a spring. This constant down-pressure results in a furrow of different depth as soil conditions such as soil hardness change. Thus, the material placement is not consistent across varying soil conditions. Inconsistent material placement can lead to lower yielding crops and other problems.

Thus, it would be desirable to develop a system that overcomes the problems and limitations associated with traditional single-disk and double-disk openers.

## SUMMARY OF THE INVENTION

In accordance with one embodiment, an agricultural row unit assembly includes an attachment frame configured for attachment to a tow bar that is movable in a direction of travel. A proximal end of a swing-arm is coupled to the attachment frame, and an opener disk is mounted to and offset from a distal end of the swing-arm for forming a furrow. A deflecting disk is mounted to the distal end for deflecting debris from entering the furrow, and is mounted between the distal end of the swing-arm and the opener disk. The deflecting disk has a top peripheral edge spaced away from a top peripheral edge of the opener disk. A support bracket is attached as a cantile-

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vered structure depending from the proximal end of the swing arm and extends in a space between the top peripheral edges. A tube is routed long the support bracket for dispensing a material into the furrow.

In accordance with another embodiment, an agricultural row unit assembly includes an attachment frame configured for attachment to a tow bar movable in a generally horizontal direction of travel. A swing-arm has a proximal end and a distal end, the proximal end being coupled to the attachment frame. An opener disk for forming a furrow is mounted to the distal end of the swing-arm. A deflecting disk is mounted to the distal end of the swing-arm between the opener disk and the distal end of the swing-arm. A support bracket has a mounted end attached to the proximal end of the swing-arm. The support bracket has an intermediate section extending in a space between top peripheral edges of the deflecting disk and the opener disk. The intermediate section terminates in a free end of the support bracket. A tube is attached to the support bracket for dispensing a material into the furrow.

## BRIEF DESCRIPTION OF THE DRAWINGS

The invention may best be understood by reference to the following description taken in conjunction with the accompanying drawings.

FIG. 1 illustrates a coordinate axis depicting pitch, yaw, and roll as used herein.

FIG. 2 illustrates a perspective view of a disk opener having a hybrid single-disk, double-disk opener arrangement, according to an aspect of the present disclosure.

FIG. 3 illustrates a second perspective view of the disk opener of FIG. 2.

FIG. 4 illustrates a top-down view of a portion of the disk opener of FIG. 2.

FIG. 5 is a cross-sectional view of a portion of the disk opener of FIG. 4 along line V-V.

FIG. 6A illustrates a rear view of a portion of the disk opener of FIG. 2.

FIG. 6B illustrates a cross-sectional view of a furrow created by the disk opener of FIG. 2.

FIG. 7 illustrates a cross-sectional view of the disk opener of FIG. 4 along line VII-VII.

FIG. 8 illustrates an exploded view of a portion of the disk opener of FIG. 2.

FIG. 9 is a side view of a disk opener with a gauge wheel attached via an extended swing-arm.

FIG. 10 is a side view of a disk opener with a closing wheel attached via a closing-wheel arm.

FIG. 11 is a side view of a disk opener with a closing wheel attached via a parallel linkage.

FIG. 12 is a perspective view of a disk opener with a parallel linkage attachment.

FIG. 13 is a left side view of FIG. 12.

FIG. 14 is a right side view of FIG. 12.

FIG. 15A is a perspective view of a swing-arm assembly with a disk opener and a support bracket.

FIG. 15B is a top view of the swing-arm assembly of FIG. 15A.

FIG. 16A is a top view of the swing-arm assembly of FIG. 15A illustrated without the disk opener.

FIG. 16B is a partial cross-sectional side view of FIG. 16A.

FIG. 16C is a partial cross-sectional front view of FIG. 16A.

FIG. 17A is a top view of the swing-arm assembly of FIG. 15A illustrated with the disk opener.

FIG. 17B is a partial cross-sectional side view of FIG. 17A.

FIG. 17C is a partial cross-sectional front view of FIG. 17A.

#### DETAILED DESCRIPTION OF ILLUSTRATED EMBODIMENTS

Although the invention will be described in connection with certain preferred embodiments, it will be understood that the invention is not limited to those particular embodiments. On the contrary, the invention is intended to cover all alternatives, modifications, and equivalent arrangements as may be included within the spirit and scope of the invention as defined by the appended claims.

Tractors are generally used to tow agricultural implements, particularly when the implement is being used to till a field. As the tractor travels along the surface of a field, the implement generally follows substantially the same path as the tractor, defining a direction of travel. The implement typically comprises a plurality of row units, each row unit generally following the direction of travel of the implement.

Turning now to the drawings and referring first to FIG. 1, a coordinate axis depicting pitch, yaw, and roll is shown. As used herein, the x-axis is generally aligned with the direction of travel. Rotation about the x-axis is typically referred to as "roll." Also as used herein, the y-axis is generally perpendicular to the x-axis and generally extends horizontally along the surface of the field. Rotation about the y-axis is generally referred to as "pitch." Further as used herein, the z-axis is generally perpendicular to both the x-axis and the y-axis and generally extends vertically from the surface of the field. Rotation about the z-axis is generally referred to as "yaw."

Referring to FIGS. 2 and 3, a disk opener 200 is shown. FIG. 2 illustrates a first perspective view of the disk opener 200. FIG. 3 illustrates a second perspective view of the disk opener 200. The disk opener 200 is coupled to a towing frame 202 that is coupled to a tractor. An attachment frame 204 rigidly connects row unit 200 to the towing frame 202. A linkage 206 couples the attachment frame 204 and a proximal end 210 of a swing-arm 208. The linkage 206 may rigidly connect the attachment frame 204 and the proximal end 210 or may allow vertical pivoting movement of the proximal end of the swing-arm 208 relative to the attachment frame 204.

The swing-arm 208 includes a distal end 212 that is movable relative to the proximal end 210. In some aspects, the proximal end 210 and the distal end 212 pivot about an axis defined by a pin 214. The distal end 212 includes a housing 216 supporting a primary disk 218, a deflecting disk 220, and a material shoe assembly 222. In some aspects, as will be described in more detail with reference to FIGS. 6A and 6B below, the primary disk 218 is configured to open at least a portion of a furrow 224 and the deflecting disk 220 is configured to deflect debris from entering the furrow 224 and/or contacting the material shoe assembly 222. As will be described in further detail with reference to FIG. 8 below, the material shoe assembly 222 is configured to deliver material such as seed or fertilizer into the furrow 224.

In one nonlimiting example, a hybrid double-disk, single-disk opener (alternatively, "hybrid disk opener") includes two disks having different diameters. In some aspects, the primary disk 218 has a first diameter and the deflecting disk 220 has a second diameter that is smaller than the first diameter. The primary disk 218 engages an amount of soil to cut the furrow and the deflecting disk 220 engages less soil than the primary disk 218 due to the smaller diameter. Advantageously, the hybrid disk opener requires less down-pressure to properly place material in the furrow 224 than a traditional double-disk opener because of the lessened soil engagement. Addition-

ally, the deflecting disk 220 provides advantages over a traditional single-disk opener for material placement at a desired depth and/or lateral spacing by substantially preventing debris from entering the furrow before the material has been placed in the furrow 224. It has also been determined that many problems associated with traditional single-disk openers, with a stationary material shoe design, including high friction, high wear, pinching by residue, and inconsistent material placement are due to debris falling into the furrow prior to passage of the material shoe. The deflecting disk 220 also provides benefits over a traditional single-disk opener by lessening wear and tear on the material shoe apparatus 222.

The disk opener 200 also comprises a wiper wheel 226 and a down-pressure mechanism 228. The wiper wheel 226 is coupled to the swing-arm 208 by a support 304 that allows movement of the wiper wheel 226 relative to the primary disk 218. The wiper wheel 226 is configured to clean soil and/or other debris from the primary disk 218 and also to gauge the soil penetration of the primary disk 218. Different soil conditions can cause many different levels of "stickiness" that result in different tendencies of soil adherence to the primary disk 218.

The down-pressure mechanism 228 is configured to apply pressure to the swing-arm 208 to assist the primary disk 218 in penetrating the soil. The down-pressure applied can be dependent on the position of at least a portion of the down-pressure mechanism 228 or can be dependent on the position of two or more components of the implement relative to each other. In some aspects, the down-pressure mechanism 228 includes a spring that applies increasing amounts of force as the spring is compressed and/or extended. In some aspects, the down-pressure mechanism 228 includes a hydraulic device that applies varying amounts of pressure as it is extended and retracted. In some aspects, as will be described in more detail with reference to FIG. 7, the down-pressure mechanism 228 includes a hydraulic device that varies an applied down-pressure dependent upon the vertical displacement of the wiper wheel 226 with respect to the primary disk 218.

Referring to FIG. 4, a top-down view of a portion of the disk opener 200 is shown with the material shoe apparatus 222 omitted. A housing 216 is disposed at the distal end 212 of the swing-arm 208. The housing 216 couples the primary disk 218 and the deflecting disk 220 to the swing-arm. A spindle (FIG. 5) is disposed within the housing and coupled to the primary disk 218. The spindle maintains the orientation of the primary disk 218 relative to the housing 216. A hub 404 is disposed about the housing 216 and is coupled to the deflecting disk 220. The hub 404 maintains the orientation of the deflecting disk 220 relative to the housing 216.

In one non-limiting example, the deflecting disk 220 is disposed behind the primary disk 218 in the direction of travel. In some aspects, a leading edge of the deflecting disk 220 is disposed behind a portion of the primary disk 218 with respect to the direction of travel. In some aspects, a leading edge of the deflecting disk 220 is aligned with a leading edge of the primary disk 218. In some aspects, the primary disk 218 has a first yaw angle  $\zeta_P$  that is yawed about the z-axis and the deflecting disk 220 has a second yaw angle  $\zeta_D$  that is yawed about the z-axis. The first yaw angle  $\zeta_P$  has a substantially greater magnitude than the second yaw angle  $\zeta_D$ . In the illustrated embodiment, the first yaw angle  $\zeta_P$  is yawed about the vertical axis in a first direction and the second yaw angle  $\zeta_D$  is yawed about the vertical axis in a second direction opposite the first direction. In one nonlimiting example, the first yaw angle  $\zeta_P$  measures between about 3° and about 7°. More preferably, the first yaw angle  $\zeta_P$  measures about 5°. In one

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nonlimiting example, the second yaw angle  $\zeta_D$  measures between about  $0^\circ$  and about  $2^\circ$ . More preferably, the second yaw angle  $\zeta_D$  measures about  $1^\circ$ . The width  $W$  of the furrow at the surface is substantially determined by the first yaw angle  $\zeta_P$  of the primary disk.

Referring to FIG. 5, a cross-sectional view of the disk of the disk opener 200 including the housing 216 is shown. The housing 216 defines a bore 502 therein and also defines a bearing seat 504 about the periphery of the housing 216. A spindle 506 is coupled to the primary disk 218 and defines a first axis of rotation of the primary disk 218. The spindle 506 is disposed within the bore 502. A plurality of bearings 508 engages the bore 502 and the spindle 506. The plurality of bearings 508 prevents radial movement of the spindle 506. In some aspects, a crown-nut 510 engages the spindle 506 and the plurality of bearings 508 to prevent longitudinal movement of the spindle 506 in a first direction. In some aspects, the spindle 506 engages the plurality of bearings 508 to prevent movement of the spindle 506 in a second direction.

The bearing seat 504 receives a plurality of bearings 512 coupled to the deflecting disk 220 via the hub 404. The plurality of bearings 512 prevents radial movement of the hub 404. In some aspects, the bearing seat 504 prevents axial movement of the deflecting disk 220 in a first direction. In some aspects, the material shoe apparatus 222 prevents axial movement of the deflecting disk 220 in a second direction.

Advantageously, the housing 216 defines the first axis of rotation and the second axis of rotation. As shown in FIG. 5, the spindle 506 passes through, but does not engage, the hub 404 and deflecting disk 220. Further, altering one axis of rotation will not affect the other axis of rotation. In one non-limiting example, the second axis of rotation is substantially aligned with the y-axis. In this non-limiting example, the first axis of rotation can be yawed at  $5^\circ$ ,  $10^\circ$ ,  $20^\circ$ ,  $30^\circ$ , etc. from the y-axis. Additionally, in this non-limiting example, the second axis may be pitched at  $5^\circ$ ,  $10^\circ$ ,  $20^\circ$ ,  $30^\circ$ , etc. from the y-axis.

Advantageously, the housing 216 may be disposed outside of the primary disk 218 and the secondary disk 220. This allows the disks to be spaced closely together because fewer components need to be disposed between the two disks. Further, the swing-arm being disposed on a single side of both disks allows easier access to the disks and components for maintenance and repairs than two swing-arms where each is disposed on the outside of each disk.

Referring to FIG. 6A, which illustrates a rear view of the primary disk 218, deflecting disk 220, wiper wheel 226 and support 304 are shown generally along the direction of motion. A vertical line 602 is illustrated extending upwardly along the z-axis. The primary disk 218 is a generally a planar disk that extends along line 604. The deflecting disk 220 is a generally planar disk that extends along line 606. The wiper wheel 226 has a generally interior surface facing the primary disk 218 that extends along line 608.

The primary disk 218 is rolled at a first angle  $\theta_P$  from vertical 602. The deflecting disk 220 is rolled at a second angle  $\theta_D$  from vertical 602 in the same direction as the first angle  $\theta_P$ . The wiper wheel 226 is rolled at a third angle  $\theta_W$  from vertical 602 in the opposite direction from the first angle  $\theta_P$ . In some aspects, the first angle  $\theta_P$  measures between about  $0^\circ$  and about  $4^\circ$ . More preferably, the first angle  $\theta_P$  measures about  $2^\circ$ . In some aspects, the second angle  $\theta_D$  measures between about  $4^\circ$  and about  $10^\circ$ . More preferably, the second angle  $\theta_D$  measures about  $7^\circ$ . In some aspects, the third angle  $\theta_W$  measures between about  $0^\circ$  and about  $4^\circ$ . More preferably, the third angle  $\theta_W$  measures about  $2^\circ$ .

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Referring to FIG. 6B, a cross-sectional view of the furrow 224 created by the disk opener of FIG. 6A is shown generally along the direction of motion. The furrow 224 has an interior wall 610 and an exterior wall 612 extending into the soil from the surface 614. The furrow 224 has a width  $W$  at the surface 614 and generally narrows to a generally parabolic bottom 618. The interior wall 610 is rolled at a first furrow angle  $\theta_{FP}$  from vertical 602. The exterior wall 610 is rolled at a second furrow angle  $\theta_{FD}$  from vertical 602 in the same direction as the first furrow angle  $\theta_{FP}$ . In some aspects, the first furrow angle  $\theta_{FP}$  is generally the same as the first angle  $\theta_P$  and measures, for example, between about  $0^\circ$  and about  $4^\circ$ ; more preferably about  $2^\circ$ . In some aspects, the second furrow angle  $\theta_{FD}$  is generally the same as the second angle  $\theta_D$  and measures, for example, between about  $4^\circ$  and about  $10^\circ$ ; more preferably about  $7^\circ$ .

When the disk opener 202 is in use, the wiper wheel 226 generally follows the surface 614 of the field. The primary disk 218 and deflector disk 220 are partially disposed in the soil at a generally constant height relative to the wiper wheel. As will be explained in more detail with reference to FIG. 7 below, the relative height may change dependent upon several factors such as soil hardness.

As the primary disk 218 travels through the soil, the leading edge begins to cut the furrow 224. A leading face 616 and a trailing edge of the primary disk 218 generally form the interior wall 610 of the furrow 224 by engaging the soil. The exterior wall 612 of the furrow 224 is also formed by the leading edge 616 of the primary disk 218 engaging the soil. The deflecting disk 220 can also assist in shaping the exterior wall 612 of the furrow 224. Advantageously, the first furrow angle  $\theta_{FP}$  allows the leading face 616 of the primary disk 218 to engage the soil such that the soil generally applies a downward force on the leading face 616. This helps to increase down-pressure on the primary disk 218. Also advantageously, the deflecting disk 220 is rolled outwardly at the second angle  $\theta_D$  to slightly engage the exterior wall 612 of the furrow. This engagement exerts a lateral force toward the primary disk 218, aiding in the engagement of the leading face 616 of the primary disk 218 and creates additional down-pressure.

Referring to FIG. 7, a cross-sectional view of the disk opener 200 is shown along line VII-VII of FIG. 4. The proximal end 210 and the distal end 212 (FIG. 2) of the swing-arm 208 pivot about pin 214 relative to each other. The down-pressure mechanism 228 includes a hydraulic pump 702 having a cylinder 704 with a piston 706 disposed therein. The hydraulic pump 702 is attached to the proximal end 210 of the swing-arm 208 using crown nut 708. The piston 706 is attached to the distal end 212 (FIG. 2) of the swing-arm 208 using pin 710 such that axial movement of the piston 706 is configured to move the proximate end 210 relative to the distal end 212 (FIG. 2). In some aspects, hydraulic pump 702 receives a pressurized fluid from a fluid reservoir through the coupler 302 (FIG. 3). The pressurized fluid is a generally incompressible fluid such as hydraulic oil. The pump 702 is configured to control the pressure of fluid in cylinder 704. Increasing the pressure of fluid in the cylinder 704 causes the down-pressure mechanism 228 to apply more downward force to the primary disk 218 and the deflector disk 220. The fluid pressure can be increased by the pump 702 forcing more fluid into the cylinder 704. Conversely, the down-pressure mechanism 228 can decrease the amount of down-pressure applied by the primary disk 218 and the deflector disk 220 by decreasing the pressure of fluid in the cylinder 704. This can be accomplished, for example, by using pump 702 to actively



remove fluid from the cylinder **704**, or may be accomplished by passively venting the cylinder **704** until the desired fluid pressure is reached.

The down-pressure applied by down-pressure mechanism **228** can be constant or can be dynamically variable depending on soil conditions. For example, soil hardness can be measured to determine the proper applied down-pressure.

In one nonlimiting example, the swing-arm **208** includes a ground-hardness sensor **816** integrated within the furrow opening device. In some aspects, the ground-hardness sensor **816** (FIG. 8) is disposed within the distal end **212** of the swing-arm **208** and is fixed relative to the swing-arm **208**. The ground-hardness sensor **816** has an aperture disposed therein and detects rotational movement of a shaft **714** disposed within the aperture. A torsion spring **712** is disposed within the swing-arm **208** and engages the shaft **714** to rotationally bias the shaft **714** toward an equilibrium point. The shaft **714** is configured to indicate the position of the wiper wheel **226** relative to the primary disk **219** and/or deflecting disk **220**. The arm **304** (FIG. 3) fixes rotation of the shaft **714** to pivotal movement of the wiper wheel **226**. Movement of the wiper wheel **226** relative to the primary disk **218** and deflecting disk **220** causes rotation of the shaft **714** within the sensor **816**. In some aspects, the ground-hardness sensor **816** is an inductive linear position sensor. The inductive linear position sensor measures movement of a cam to determine movement of the wiper wheel **226** relative to the primary disk **218** and the deflecting disk **220**.

In this non-limiting example, increased soil hardness will cause the primary disk **218** and deflecting disk **220** to cut a shallower furrow and, thus, rise relative to the wiper wheel **226**. The shallower penetration will cause the shaft **714** to rotate from a home position in a counter-clockwise direction relative to the sensor **816**. The sensor **816** detects the direction of the rotation and causes the down-pressure mechanism **228** to increase the applied down-pressure until the shaft **714** rotates clockwise and returns to the home position. Once in the home position, the down-pressure mechanism **228** maintains the down-pressure.

Alternatively, a decrease in soil hardness will cause the primary disk **218** and deflecting disk **220** to cut a deeper furrow and, thus, drop relative to the wiper wheel **226**. The deeper penetration will cause the shaft **714** to rotate from the home position in a clockwise direction relative to the sensor **816**. The sensor **816** detects the direction of the rotation and causes the down-pressure mechanism **228** to lower the applied down-pressure until the shaft **714** rotates counter-clockwise and returns to the home position. Once in the home position, the down-pressure mechanism **228** maintains the down-pressure.

Advantageously, dynamic variation of applied down-pressure allows the disk opener to create a consistent furrow depth independent of variation in ground hardness. This also allows consistent placement of material such as seed or fertilized. Consistent depth of seed placement is especially important in certain types of seed such as corn because uniform emergence and growth of plants leads to increased yields and crop health.

Referring to FIG. 8, an exploded view of a portion of the disk opener **200** is shown. Two bearings **214b** are disposed within the swing-arm **208** and configured to engage the pin **214** such that the proximate end **210** can pivot relative to the distal end **212**. The pin **710** is disposed within the swing-arm **208**. Nut **710a** and washer **710b** are used to prevent axial movement of the pin **710**.

The deflecting disk **220** is coupled to the hub **404** using a plurality of fasteners. The bearing seat **504** receives the bear-

ings disposed within hub **404**. The hub **404** is prevented from axial movement by the bearing seat **504** and the material shoe apparatus **222**.

The material shoe apparatus **222** includes a material shoe **802** and a mounting bracket **804**. The mounting bracket **804** includes an aperture **806** configured to receive a portion of the housing **216**. The aperture **806** includes a plurality of teeth **808a** disposed therein and configured to engage a corresponding plurality of notches **808b** on the housing **216**. When the teeth **808a** engage the notches **808b**, the mounting bracket **804** cannot rotate relative to the housing **216**. Axial movement of the mounting bracket is prevented by a fastener such as a snap ring **812** engaging the housing **216**. The material shoe **802** is pivotably mounted to the bracket **804** using a pin **810** secured by a fastener (not shown). The pin **810** allows the material shoe **802** to be easily removed for maintenance or repair.

The spindle **506** is coupled to and extends from the primary disk **218**. The spindle **506** is disposed within the housing **216** and extends through the fastener **812**, the aperture **806**, the hub **404** and deflecting disk **220**, the bearing **508**, and washer **509**. The crown nut **510** is threaded onto the spindle **506** and fixed relative to the spindle **506** using, for example, a Cotter key. A cap **814** engages the housing **216** and prevents debris from entering the bore **502**.

The arm **304** is configured to pivot about shaft **714** as the gauge wheel **226** moves along the surface of the field. The shaft **714** is received by the sensor **816**. The shaft is prevented from axial movement by a fastener such as nut **714a**. The sensor **816** includes an indicator configured to indicate a condition of the ground-hardness sensor **816**. In some aspects, the indicator displays a green light when the ground-hardness sensor **816** is functioning properly and a red light when the ground-hardness sensor **816** is malfunctioning. The indicator is disposed behind a clear plastic cover **818**. Clear plastic is used so that the indicator can be readily seen by an operator without the need for removing any parts from the device. Two electrical wires **820** are connected to the sensor **816** in order to power the sensor and/or carry data from the sensor to, for example, a processor. In one nonlimiting example, the ground-hardness sensor **816** outputs an analog signal that varies as the position of the wiper wheel **226** changes relative to the primary disk **218**. In another nonlimiting example, the ground-hardness sensor **816** outputs a digital signal that conveys the position of the wiper wheel **226** relative to the primary disk **218**.

In some aspects, a scraper or protrusion is used to remove soil and debris from the primary disk blade. In other aspects, the deflecting disk includes a scraper, protrusion, or wiper wheel to remove soil and debris from the deflecting disk. In yet other aspects, a gauge wheel is used in place of the wiper wheel **226** and does not clean the primary disk **218**.

Referring to FIG. 9, a disk opener row unit **900** includes one or more features similar to or identical to features described above in reference to FIGS. 1-8, but in addition or alternatively has a gauge-wheel arm **902** for attaching a gauge wheel **904** (also previously referred to as a wiper wheel) such that the gauge wheel **904** completely trails at least one opener disk **906**. In other words, the gauge-wheel arm **902** is longer than the support **304** (FIG. 3) to allow placement of the gauge wheel **904** much farther relative to a pivoting axis **908** of a swing-arm **910**. In this exemplary configuration, a leading edge of the gauge wheel **904** is located rearwardly of a trailing edge of the opener disk **906**. The location of the gauge wheel **904** relative to the opener disk **906** is described relative to the direction of travel.

Some of the features of the disk opener row unit **900** include an attachment frame **912** for rigidly attaching the swing-arm **910** to a tow bar (not shown), and a hydraulic cylinder **914**. The hydraulic cylinder **914** applies pressure to the swing-arm **910**, to control the downwards force exerted by the opener disk **906** in forming a furrow. The hydraulic cylinder **914** can lower or raise the opener disk **906**, as applicable.

Referring to FIG. **10**, a disk opener row unit **1000** includes one or more features similar or identical to features described above in reference to FIGS. **1-9**, but in addition or alternatively has a closing-wheel arm **1002** for attaching at least one closing wheel **1004**. The closing-wheel arm **1002** attaches the closing wheel **1004** to a swing-arm **1006**, to which at least one opener disk **1008** and a gauge wheel **1010** are also attached. The swing-arm **1006** is rigidly attached to a tow bar (not shown) via an attachment frame **1012** and has a controllable force applied via a hydraulic cylinder **1014**.

In this example, the closing-wheel arm **1002** is shaped with an upward curvature to prevent physical interference between the closing-wheel arm **1002** and the opener disk **1008**, the gauge wheel **1010**, or a gauge-wheel arm **1016**. In other examples, the closing-wheel arm **1002** can have other shapes and/or be attached to other attachment points of the disk opener row unit **1000**.

In the illustrated example, the closing wheel **1004** is a toothed wheel such as a CURVETINE™ wheel manufactured by Dawn Equipment Company (assignee of the present application). In other examples, the closing wheel **1004** can be any type of closing wheel, including smooth rubber wheels, smooth cast-iron wheels, wedge wheels, spiked wheels, etc.

Optionally, the disk opener row unit **1000** includes a pair of closing wheels **1004**. The closing wheels **1004** can be both attached to the same closing-wheel arm **1002** or can each have its own closing-wheel arm **1002**. According to one example, the closing wheels **1004** are symmetrically attached to the closing-wheel arm **1002**, to the swing-arm **1006**, or to any other portion of the disk opener row unit **900**.

Referring to FIG. **11**, a disk opener row unit **1100** includes one or more features similar or identical to features described above in reference to FIGS. **1-10**, but in addition or alternatively has a parallel linkage **1102** for attaching at least one closing wheel **1104**. The parallel linkage **1102** is attached to an attachment frame **1106**, which, in turn, is rigidly attached to a tow bar (not shown). Similar to disk opener row units described above, the disk opener row unit **1100** includes at least one opener disk **1108** attached to the attachment frame **1106** via a swing-arm **1110**, a gauge wheel **1112**, and a hydraulic cylinder **1114** for applying a controllable force to the opener disk **1108**.

The parallel linkage **1102** is a conventional four-bar linkage assembly used in agricultural implements to permit the raising and lowering of tools attached thereto. The parallel linkage **1102** includes a pair of parallel upper links **1116** and a pair of parallel lower links **1118** that are interconnected to permit up-and-down movement of the closing wheel **1104**. Optionally, the parallel linkage **1102** includes its own hydraulic cylinder **1120** for applying a controllable force to the closing wheel **1104**.

Referring to FIGS. **12-14**, a disk opener row unit **1200** includes one or more features similar or identical to features described above in reference to FIGS. **1-11**, but alternatively is attachable to a tow bar via a parallel linkage **1202** (instead of a swing-arm type attachment). The disk opener row unit **1200** further includes at least one opener disk **1204** (attached via a disk arm to the parallel linkage **1202**), a gauge wheel **1206** (attached via a gauge-wheel arm **1208**), and a hydraulic cylinder **1210**.

The parallel linkage **1202** is pivotably coupled to a towing frame **1212** (which is attachable to a tow bar) and permits

movement of the opener disk **1204** relative to the tow bar. The hydraulic cylinder **1210** provides a controllable force for applying down or up pressure to the opener disk **1204**. According to one example, the parallel linkage **1202** is a FREEFARM LARGE LINKAGE, which is manufactured by Dawn Equipment Company, weighs approximately 250 pounds, and provides up to about 16 inches of vertical travel.

Referring to FIG. **15A**, a swing-arm assembly **1300** includes a swing-arm **1302** and is adapted for use in a disk opener assembly, such as the disk openers **200**, **900**, **1000**, **1100**, **1200** described above and illustrated in FIGS. **2-14**. The swing-arm **1302** has a housing **1304** at a distal end **1302a** and a pin **1306** at a proximal end **1302b**. The swing-arm assembly **1300** and at least some of its components are similar, but necessarily identical, to counterpart components described above in reference to the identified disk openers.

A pair of disks, including a primary disk (or primary blade) **1308** and a deflecting disk (or deflecting blade) **1310**, are mounted to the distal end **1302a** of the swing-arm **1302**. The swing-arm assembly **1300** further includes a support arm **1312** (illustrated in FIG. **15B**) extending from the proximal end **1302b** of the swing-arm **1302**. A gauge wheel **1314** is mounted to the support arm **1312** via a shaft **1316** (illustrated in FIG. **15B**).

In addition to or instead of counterpart components described above in FIGS. **2-14** in reference to alternative embodiments, the swing-arm assembly **1300** includes a support bracket **1318** and a fertilizer tube **1320**. The support bracket **1318** has a mounted end **1318a** attached to the proximal end **1302b** of the swing-arm **1302**. The support bracket **1318** has a free end **1318b** extending past the distal end **1302a** of the swing-arm **1302**. Thus, the support bracket **1318** is a cantilevered structure depending from the swing-arm **1302**. In-between the two ends **1318a**, **1318b**, the support bracket **1318** has an arch-shaped section **1318c** that generally follows the shape of the primary disk **1308**.

The fertilizer tube **1320** is attached to a bottom edge of the support bracket **1318** and is contoured similar to the shape of the support bracket **1318**. The fertilizer tube **1320** is adapted to expel a liquid fertilizer or other liquids into a formed furrow. Alternatively, the fertilizer tube **1320** is a tube that dispenses seeds or other solids into the formed furrow. According to one example, the fertilizer tube **1320** is a hose affixed to or routed through the support bracket **1318**.

Referring to FIG. **15B**, the arch-shaped section **1318c** and the free end **1318b** of the support bracket **1318** are located in a space **1322** between the primary disk **1308** and the deflecting disk **1310**. The space **1322** would otherwise be empty without the support bracket **1318**. As such, one benefit of the support bracket **1318** is that its shape and mounting position efficiently uses the limited available space in the swing-arm assembly **1300**.

Referring to FIG. **16A**, the support bracket **1318** extends linearly between the support arm **1312** and the distal end **1302a** of the swing-arm **1302**. The mounted end **1308a** is fixed directly to the swing-arm **1302** via a pair of bolts **1324** that are threaded into respective bolt holes **1326** (illustrated in FIG. **16B**). The free end **1318b** of the support bracket **1318** extends a distance **D** from the mounted end **1308**, and is positioned a distance **X** from the outer periphery of the gauge wheel **1314**.

Referring to FIG. **16B**, the fertilizer tube **1320** extends a distance **L** beyond the free end **1318b** of the support bracket **1318**. The support bracket **1318** has a generally uniform width **W** along the arch-shaped section **1318c** that is greater than a diameter **A** of the fertilizer tube **1320**. In other embodiments, the width **W** and the diameter **A** can have any dimension and can have a varying shape. In particular, the support bracket **1318** provides a stable supporting structure for the fertilizer tube **1320**.

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The mounted end **1318a** of the support bracket **1318** is adjacent to a torsion spring **1328** that is mounted internally within the swing-arm **1302**. The torsion spring compresses **1328** to dampen force effects when the swing-arm **1302** rotates, providing a smooth change in movement for the swing-arm **1302**.

Referring to FIG. 16C, the support bracket **1318** is slightly angled in a vertical direction relative to the swing-arm **1302** and the support arm **1312**. In other embodiments, the support bracket **1318** can have other angles of orientations that do not interfere mechanically with components of the swing-arm assembly **1300**.

Referring to FIGS. 17A-17C, the illustrated views are counterpart views of FIGS. 16A-16C, respectively, except that the primary and deflecting disks **1308**, **1310** are also illustrated to further illustrate the position of the support bracket **1318** in the space **1322** between the primary disk **1308** and the deflecting disk **1310**. Specifically, as illustrated in FIG. 17C, the support bracket **1318** is angled from the primary disk **1308** and the deflecting disk **1310** at respective angles  $\alpha$  and  $\beta$ , respectively. The clearance provided by angles  $\alpha$  and  $\beta$  help prevent physical interference between the support bracket **1318** (and attached fertilizer tube **1320**) and the disks **1308**, **1310**.

Furthermore, in reference to FIG. 17B, the primary disk **1308** has a radius R1 that is generally greater than a distance R2, which extends from a center point O of the primary disk **1308** to a top edge of the support bracket **1318**. As such, the support bracket **1308** (and fertilizer tube **1320**) is protected from debris and/or other environmental conditions by the primary disk **1308** and/or the deflecting disk **1310**. The radius of the deflecting disk **1310** is at least about the same as the distance R2.

The bottom edge of the fertilizer tube **1320** is at a smaller distance R3 from the center point O, and is intended to maximize the distance between the fertilizer tube **1320** and debris, such as dirt and rocks, thrown by the primary disk **1308**. In this embodiment, the distances R1 and R2 are generally radial distances. However, in other embodiments the distances R1 and R2 can be any distance that eliminates mechanical interference between the support bracket **1318** and other components of the swing-arm assembly **1300**, and that locates the support bracket **1318** and the fertilizer tube **1320** into an area generally protected from debris or other adverse environmental conditions.

It will be evident to those skilled in the art that the invention is not limited to the details of the foregoing illustrated embodiment and that the present invention may be embodied in other specific forms without departing from the spirit or essential attributes thereof. The present embodiment is therefore to be considered in all respects as illustrative and not restrictive, the scope of the invention being indicated by the appended claims rather than by the foregoing description, and all changes which come within the meaning and range of equivalency of the claims are therefore intended to be embraced therein.

The invention claimed is:

1. An agricultural row unit assembly comprising: an attachment frame configured for attachment to a tow bar movable in a direction of travel;
- a swing-arm having a proximal end and a distal end, the proximal end being coupled to the attachment frame;
- an opener disk mounted to and offset from the distal end of the swing-arm for forming a furrow;
- a deflecting disk mounted to the distal end of the swing-arm for deflecting debris from entering the furrow, the deflecting disk being mounted between the distal end of the swing-arm and the opener disk, the deflecting disk having a top peripheral edge spaced away from a top peripheral edge of the opener disk;

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- a support bracket attached as a cantilevered structure depending from the proximal end of the swing-arm, the support bracket extending in a space between top peripheral edges of the deflecting disk and the opener disk; and
- a tube routed along the support bracket for dispensing a material into the furrow.

2. The agricultural row unit assembly of claim 1, wherein the support bracket has a mounted end, a free end, and an intermediate arch-shaped section.

3. The agricultural row unit assembly of claim 2, wherein the mounted end of the support bracket is fixed directly to the proximal end of the swing-arm.

4. The agricultural row unit assembly of claim 2, wherein the opener disk has a radius R1 and the intermediate arch-shaped section has a top edge that is a distance R2 from a center point O of the opener disk, the radius R1 being greater than the distance R2.

5. The agricultural row unit assembly of claim 4, wherein the intermediate arch-shaped section has a radial contour, the distance R2 being a radial distance.

6. The agricultural row unit assembly of claim 2, wherein the tube extends past the free end of the support bracket by a distance L.

7. The agricultural row unit assembly of claim 1, wherein the support bracket has a mounted end, a free end, and an intermediate section, the tube being attached directly to a bottom edge of the intermediate section.

8. The agricultural row unit assembly of claim 1, wherein the space between the top peripheral edges of the deflecting disk and the opener disk is defined by respective angles  $\alpha$  and  $\beta$ , angle  $\alpha$  being an angle between the support bracket and the opener disk, angle  $\theta$  being an angle between the support bracket and the deflecting disk.

9. The agricultural row unit assembly of claim 1, wherein the material being dispensed is selected from a group consisting of a fertilizer and a seed.

10. The agricultural row unit assembly of claim 1, wherein the support bracket is fastened with at least one bolt to the swing-arm.

11. An agricultural row unit assembly comprising: an attachment frame configured for attachment to a tow bar movable in a generally horizontal direction of travel;
- a swing-arm having a proximal end and a distal end, the proximal end being coupled to the attachment frame;
- an opener disk for forming a furrow and mounted to the distal end of the swing-arm;
- a deflecting disk mounted to the distal end of the swing-arm between the opener disk and the distal end;
- a support bracket having a mounted end attached to the proximal end of the swing-arm, the support bracket having an intermediate section extending in a space between top peripheral edges of the deflecting disk and the opener disk, the intermediate section terminating in a free end of the support bracket; and
- a tube attached to the support bracket for dispensing a material into the furrow.

12. The agricultural row unit assembly of claim 11, wherein the mounted end of the support bracket is fixed directly to the proximal end of the swing-arm.

13. The agricultural row unit assembly of claim 11, wherein the opener disk has a radius R1 and the intermediate section has a top edge that is a distance R2 from a center point O of the opener disk, the radius R1 being greater than the distance R2.

14. The agricultural row unit assembly of claim 11, wherein the intermediate section has a radial contour.

15. The agricultural row unit assembly of claim 11, wherein the tube extends past the free end of the support bracket by a distance L.

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16. The agricultural row unit assembly of claim 11, the tube is attached directly to a bottom edge of the intermediate section.

17. The agricultural row unit assembly of claim 11, wherein the space between the top peripheral edges of the deflecting disk and the opener disk is defined by respective angles  $\alpha$  and  $\beta$ , angle  $\alpha$  being an angle between the support bracket and the opener disk, angle  $\beta$  being an angle between the support bracket and the deflecting disk. 5

18. The agricultural row unit assembly of claim 11, wherein the material being dispensed is selected from a group consisting of a fertilizer and a seed. 10

19. The agricultural row unit assembly of claim 11, wherein the mounted end of the support bracket is fastened with at least one bolt to the proximal end of the swing-arm. 15

20. The agricultural row unit assembly of claim 11, wherein bottom peripheral edges of the opener disk and the deflecting disk are closer to each other than the top peripheral edges of the opener disk and the deflecting disk.

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